Clinic variation in glycaemic control for children with Type 1 diabetes in England and Wales

Clinic variation in glycaemic control for children with Type 1 diabetes in England and Wales: a population-based, multilevel analysis

Running head: A multilevel analysis of variation in glycaemic control for children with Type 1 diabetes in England and Wales

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What's new

- This is the first population-based study to quantify the impact of clinic context on glycaemic control of children with Type 1 diabetes in the UK using robust multilevel techniques.
- We found significant differences between diabetes clinics over and above individual characteristics. However, clinic differences accounted for only a small portion of the total variation in glycaemic control and most of the variation was within clinics. This suggests that glycaemic improvements at a national level might best be achieved not only by targeting poor clinics but also by shifting the whole distribution of clinics to higher levels of quality.
- Children who attended clinics with more consistent glycaemic results had significantly better glycaemic control.

Abstract

Aims: To determine the scope for improving children's glycaemic outcomes by reducing variation between clinics and examine the role of insulin regimen and clinic characteristics.

Methods: Cross-sectional analysis of 2012-13 National Paediatric Diabetes Audit data from 21,773 children <19 years with Type 1 diabetes cared for at 176 clinics organised into 11 regional diabetes networks in England and Wales. Variation in glycated haemoglobin (HbA_{1c}) was explored by multilevel models with a random effect for clinic. The impact of clinic context was quantified by computing the % of total variation in HbA_{1c} which occurs between clinics -Intraclass Correlation Coefficient (ICC).

Results: Overall, 69 of the 176 diabetes clinics (39%) had a glycaemic performance which differed significantly from the national average after adjusting for patient case-mix with respect to age, gender, diabetes duration, deprivation and ethnicity. However, differences between clinics accounted for 4.7% of the total variation in HbA_{1c}. Inclusion of within-clinic HbA_{1c} standard deviation led to a substantial reduction in ICC to 2.4%. Insulin regimen, clinic volume, and diabetes networks had a small or moderate impact on ICC.

Conclusions: Differences between diabetes clinics accounted for only a small portion of the total variation in glycaemic control. This implies that national glycaemic improvements might best be achieved not only by targeting poor centres but also by shifting the whole distribution of clinics to higher levels of quality.

Introduction

The UK has the fourth largest paediatric diabetes population in Europe and the fifth largest population in the world (1, 2), with the most recent estimates indicating at least 29,000 children under 19 years have T1D in the country (3, 4). Over the last decade, governmental bodies and national organisations have set specific standards of care and guidelines for children with diabetes in the UK (5-8). However, performance of England and Wales is poor when compared with similar European countries (9, 10). In 2012, less than one in five children and young people with diabetes in England and Wales met the NICE recommended HbA_{1c} target of <58 mmol/mol (7.5%) (11). Results from the 2012 NHS Diabetes Atlas of Variation reported wide regional variations in diabetes outcomes for children thus addressing the issue of unwarranted variation in paediatric diabetes care (12). National audit reports have supported these findings by describing consistently large differences between paediatric diabetes clinics in England and Wales (13). Reduction of clinic variations was identified as a clear priority in the 2012 National Paediatric Diabetes Service Improvement Delivery Plan, which also set an aim to reduce national levels of HbA_{1c} by 16 mmol/mol (1.5%) by 2023 (14).

Several multi-centre studies have looked at glycaemic differences between paediatric clinics (15-22). However, one major obstacle to effective policy action regarding unwarranted variation, as explored by previous studies, is that it is conceptualised as absolute differences between clinic means. Glycaemic outcomes can vary both between and within clinics. In addition to differences between clinics, we need to consider the share of the total variation in the glycaemic control that exists between clinics. This idea corresponds to the concept of clustering (23). Understanding how health outcomes are geographically clustered in the population is of crucial importance for policy development and implementation (24). For

example, if children's metabolic control is uniformly achieved across clinics (low clustering), then policies aiming to reduce centre variation by targeting low performing clinics may narrowly miss most poorly controlled children in the country. Conversely, if glycaemic outcomes are heterogeneously distributed across clinics (high clustering), then policies that target all clinics in the country will see many resources inefficiently delivered to areas at the smallest need.

The overall aim of the current study was therefore to determine the scope for improving children's glycaemic outcomes by reducing variation between clinics. More specifically, the objectives were to describe the extent of variation in glycaemic control between and within clinics; explore the general contribution of clinics to understanding differences in children's glycaemic outcomes; determine whether the influence of clinic context can be explained by differences in insulin regimen or other characteristics of the clinics, and investigate how clinic-level factors are associated with children's metabolic control.

Methods

Study design and population

We conducted a secondary analysis of nationwide data from the National Paediatric Diabetes Audit (NPDA) – the national audit of diabetes care for children and young people in England and Wales. Diabetes clinics are organised into 11 regional Paediatric Diabetes Networks (10 in England plus Wales). The study included all children aged <19 years with type 1 diabetes who received care in paediatric diabetes clinics in England and Wales between April 1, 2012 and March 31, 2013 (13). We included children with a duration of diabetes of at least 3 months since levels of HbA_{1c} immediately adjacent to diagnosis are not reflective of ongoing diabetes control. We excluded 251 children who changed clinic during the audit year and

children with missing information on age (n=3), gender (n=9), ethnicity (n=121), deprivation (n=190) and duration of diabetes (n=208). Clinics were included if they had at least 10 children. The adoption of this threshold reflected the need to keep a balance between excluding as few clinics as possible and excluding clinics for which the amount of data was too small to be representative. One clinic with one eligible child was excluded leaving a final study population of 21,773 children across 176 clinics.

NPDA has approval from the Confidentiality Advisory Group of the Health Research Authority to collect patient data under section 251 of the NHS Act 2006 (Reference No: ECC 2-03 (c)/2012). No additional ethics approval was required.

Measures

Outcome variable

Glycaemic control was assessed by levels of HbA_{1c} reported in standardised concentrations of mmol/mol in accordance with the International Federation of Clinical Chemistry (IFCC) (25). HbA_{1c} values submitted to NPDA in Diabetes and Complications Trial (DCCT) units of percentage were converted to mmol/mol using the formula: IFCC (mmol/mol) = (10.93 × DCCT (%)) -23.50 (26). The mean HbA_{1c} value over the audit year for each patient was used in the current analyses.

Case-mix variables

To ensure a fair comparison between clinics, we adjusted our analyses for glycaemic determinants which are beyond the control of the clinic without removing differences that may be attributable to the quality of diabetes care (27). These included age (continuous variable), gender, duration of diabetes (four categories: <1 year, 1 year, 2-4 years, and ≥ 5

years), ethnicity (6 categories: white, mixed, black, Asian, other, "not reported"), and deprivation (5 quintiles). Deprivation was derived by linking patient post codes to the 2010 and 2011 Indices of Multiple Deprivation (IMD) for England (28) and Wales (29) respectively. We used small-area IMD as a proxy for individual socio-economic status. The IMD combines information from several domains (income, employment, education, health, housing and services, crime, and living environment) to produce a single score which is a relative ranking of small areas. An adjusted UK-wide IMD score was generated following established methodology (30). Interaction terms between age and diabetes duration contributed significantly to the explanatory power of the model and were retained in the models.

Insulin regimen and clinic characteristics

We considered four factors related to diabetes care; one measured at individual level (insulin regimen) and three at the level of the clinic (regional network, clinic volume, and within-clinic glycaemic variability). Insulin regimen was classified by intensity as ≤3 injections/day, ≥4 injections/day and insulin pump therapy. For each clinic we also computed three variables; these included the regional network to which the clinic belongs, the total number of eligible children being served by the clinic (clinic volume), and the standard deviation of HbA_{1c} measurements (within-clinic HbA_{1c} variability). Data for insulin regimen were missing for 2,933 children (13.5%). To minimize loss of information, missing data on insulin regimen were imputed using Multiple Imputation Chained Equations under a missing at random assumption (31). Imputed results were broadly similar to those using observed values (see supplemental File S1 for details on imputation model and complete case analysis); in the analysis examining the role of insulin regimen imputed findings are presented in this paper.

Statistical analysis

We used a two-level multilevel model of children clustered within clinics to partition total variation in HbA_{1c} into two components: variation between clinics and variation within clinics (i.e. between children). We also adjusted for children's case-mix characteristics (gender, age, duration of diabetes, age-duration interactions, ethnicity, and deprivation quintile) as fixed effects. To visualise variation between adjusted clinic means, we used clinic estimates with 95% CI derived from the adjusted two-level model and plotted them against the national average. The above clinic estimates are akin to comparing clinics as if they had the same case-mix profile of children. Clinic estimates incorporate a "shrinkage factor" to correct for random variation, with less precise estimates from small clinics being weighted towards the national average. Clinics for which the upper 95% CI limit was lower than the national average were considered as performing "better than average", while clinics whose lower 95% CI limit exceeded the national average were classified as "poorer than average". Finally, clinics whose CI limits crossed the national average were categorised as "average".

To better understand the scope for improvements in glycaemic outcomes, we need to consider variation between clinics relative to the total variation, that is variation between and within clinics. Ascertaining the relative importance of clinics, after considering children's case-mix characteristics, can provide important clues about how glycaemic control is distributed. To explore this, we calculated the Intraclass Correlation Coefficient (ICC) which represents the proportion of total variation in glycaemic control which occurs between clinics, i.e. $ICC = \frac{between\ clinic\ variance}{between\ cinic\ +within\ clinic\ variance}$ (32). To illustrate the potential of a clinic-based approach to improve glycaemic control at a national level, we constructed a simple table by calculating the proportion of children with good (<58 mmol/mol; 7.5%),

moderate (58-80 mmol/mol; 7.5%-8.5%) and poor glycaemic control (>80 mmol/mol; 8.5%) in each of the three clinic classifications identified by the two-level case-mix adjusted model.

Having established the share of total variation in HbA_{1c} that exists between clinics, we then sought to investigate whether service-related factors could explain the "effect" of clinic context on individual glycaemic control. To explore this aspect, we extended the two-level case-mix adjusted model by separately introducing individual insulin regimen, regional network structure, clinic volume and clinic HbA_{1c}-SD and looking at changes in ICC. Attenuation of the relative clinic effect was judged by reduction in ICC. We also examined how the above three clinic-level factors are related to children's glycaemic outcomes. Clinic volume and HbA_{1c}-SD were simultaneously entered in the model since larger clinics are more likely to exhibit greater variability. Inclusion of quadratic terms for clinic volume and HbA_{1c}-SD did not improve model fit indicating that their association with glycaemic control was adequately described as linear.

Parameters were estimated using the maximum likelihood method. Model fit was examined by using the likelihood ratio test (LRT). Distribution of individual and clinic-level residuals were checked in all models and showed approximate normality. Statistical analyses were performed using Stata 13.

Results

Extent of variation in glycaemic control between and within clinics

The characteristics of children and clinics are presented in Table 1. Clinic volume ranged from 34 to 398 children. Figure 1 shows how actual HbA_{1c} levels vary both within and between the 176 paediatric diabetes clinics in England and Wales. The width of the box-and-whisker plots shows the spread of individual HbA_{1c} values within the clinics. The standard

deviation of individual HbA_{1c} values ranged across clinics from 11 mmol/mol (1.0%) to 25 mmol/mol (2.3%). Clinic means are represented by the red diamond and their spread around the national average value of 72 mmol/mol (8.8%) indicates the degree of variability that exists between clinics. Two things are worth noticing from this figure. First, glycaemic control varies more within than between clinics resulting in a considerable overlap between the clinic individual distributions. Second, clinics with poorer average glycaemic performance tend to have children with more variable glycaemic outcomes.

Figure 2 shows the estimates of clinic means with 95% confidence intervals derived from the case-mix adjusted two-level model. On average, adjusted clinic means deviated around the national average by 3.5 mmol/mol (0.3%) (standard deviation of "clinic effect"). As shown in figure 2, clinics in the bottom 2.5% of the distribution had a glycaemic difference of around 14 mmol/mol [1.3%] as compared to clinics located at the top 2.5%. Overall, 69 of the 176 practices (39%) had an adjusted HbA_{1c} value that deviated significantly from the national average. Of them, 34 practices performed below average and 35 performed above average.

General contribution of clinics to total variation in glycaemic control

To address the contribution of clinics in explaining variation in children's glycaemic outcomes, the proportion of the total variation that is located between clinics (i.e. ICC) was calculated (Table 2). The unadjusted model showed that only 5.4% of the total variation occurred between clinics. After controlling for individual case-mix characteristics, ICC slightly reduced to 4.7%, with the remaining variation (95.3%) being located within clinics. Table 3 uses the multilevel typology to show how children with different levels of glycaemic control are distributed across clinics. Of the 5,333 children with a poor glycaemic control, 1,546 (28%) received their care in one of the 35 poorly performing clinics. Although this is

higher than the 19% expected by chance, most poorly controlled children (72%) were treated by non-poorly performing clinics.

Role of insulin regimen and clinic characteristics

As sown in Table 2, ICC was only marginally affected when insulin regimen and clinic volume were fitted in the case-mix adjusted model (ICC slightly reduced to 4.2% and 4.5% respectively). Inclusion of network structure in the model led to a moderate reduction in ICC to 4.2%, however addition of networks did not give a better fit to the national data compared to the case-mix adjusted model (p-value of LRT=0.06). In contrast, addition of HbA_{1c}-SD explained almost half of the clinic variability leading to a substantial reduction in ICC to 2.4%.

We further explored the association of HbA_{1c} with clinic characteristics. Figure 3 shows mean network HbA_{1c} values after controlling for children's case-mix profile and clinic characteristics. Although some significant differences between networks are noticed (e.g. East Midlands and South Central vs East of England), overall, there is a substantial overlap in their confidence intervals.

Figure 4 shows how clinic volume and clinic HbA_{1c}-SD related to glycaemic outcomes after adjustment for case-mix characteristics and clinic differences. Children who attended larger clinics and clinics with more consistent glycaemic results (i.e. lower HbA_{1c}-SD) had significantly better glycaemic outcomes. However, as shown by the difference in the slopes, the magnitude of the association was larger for HbA_{1c}-SD (9.8 mmol/mol reduction in HbA_{1c} (95% CI 8.2 to 11.5) per 10 mmol/mol (0.9%) decrease in clinic HbA_{1c}-SD) compared to clinic volume (0.9 mmol/mol reduction in HbA_{1c} (95% CI 0.2 to 1.5) per 100 children increase in clinic volume).

Discussion

This study explored the importance of clinic context for understanding glycaemic differences in children with Type 1 diabetes. To convey the magnitude of potentially unwarranted variation between diabetes practices, we first examined glycaemic differences between clinics after adjusting for the case-mix composition of clinics. We also looked at the amount of variation that exists within clinics and expressed practice variation as a proportion of the total variability in glycaemic outcomes. This allowed us to better understand the scope for glycaemic improvements that might be possible by reducing variation between clinics.

We explored the extent of clinic variation after controlling for patient case-mix and showed that two out of five practices had a glycaemic performance which differed significantly from the national average with some centres achieving better levels of glycaemic control than others. We also observed that practices with typically good glycaemic control had a glycaemic difference of 14 mmol/mol [1.3%] as compared to practices with a typically poor glycaemic performance. The above suggest that the magnitude of clinic variation is of clinical importance. Reduction of practice variations should be a strategic goal of diabetes systems to ensure optimal care is provided to all children with type 1 diabetes regardless of the clinic they attend.

A second implication arises from the finding that clinics explained a small portion of the total variation in glycaemic control (i.e. 4.7%) and that most of the variation was within clinics and potentially attributable to unmeasured patient characteristics. Calculating the relative contribution of clinic differences as a share of the total variability in glycaemic control is important for policy making. For example, it is quite possible to have quite large differences between clinics and still show a low ICC if the variation that occurs within clinics is sufficiently large. This is precisely the situation revealed in our study. The health

policy implications of a low ICC were also illustrated by using a substantive typology of clinic's glycaemic performance. We showed that interventions targeting only poor clinics would fail to capture most children in need because they are quite unvaryingly distributed across clinics. This suggests that nationwide improvements in glycaemic control might best be achieved not only by targeting poor performers but also by shifting the whole distribution of clinics to higher levels of quality. The recent change in NICE guidelines for children with T1D towards tighter HbA_{1c} targets of less than 48 mmol/mol (6.5%) in 2015 (33) could potentially help towards this direction. Patient-centered policies have also been shown to facilitate whole system improvements (34). Here, the introduction of patient-reported experience measures (PREM) for paediatric diabetes care in England and Wales in 2013 (35) could be used as an effective tool to encourage local changes in all clinics, even those identified as performing well.

To gain a better insight into how clinic context might impact on glycaemic outcomes we further examined the role of factors related to diabetes care. Firstly, we showed that insulin regimen had a small impact on ICC. This is consistent with other studies which also found that clinic differences could not be explained by type and dose of insulin treatment (16, 17, 19). This suggests that aspects of diabetes care other than insulin regimens on offer might explain how clinics contribute to differences in children's metabolic control. We also found that children treated in larger clinics had better glycaemic control, regardless of their case-mix characteristics. This might reflect a tendency for larger clinic size to provide more specialised care, however, a reduction of 1 mmol/mol per additional 100 children was of little clinical significance. We also found that clinic size explained only a small proportion of the "clinic effect". Taken together, the above findings suggest that there are unlikely to be any meaningful effects from centralisation of paediatric diabetes units into higher volume centres.

Our findings also showed that the contribution of regional networks on children's glycaemic control was limited after controlling for children and clinic characteristics. However, it is important to emphasise that this finding does not indicate that regional networks have no important role to play in the way diabetes care is structured and delivered across clinics; instead networks might provide an efficient arena for the implementation of national guidelines and dissemination of interventions, such as encouraging young people and carer participation, broadening of stakeholder engagement, mapping resources and staffing levels, and identifying areas of service improvement (36).

We explicitly modelled within-clinic variability as a clinic-level variable and found that children who attended clinics with more consistent glycaemic results had significantly better glycaemic control. This finding agrees with results from the Hvidore study group who reported better glycaemic performance in centres where the multidisciplinary team set consistent glycaemic targets (30). We also found that within-clinic variability explained half of the clinic differences. Glycaemic consistency requires focusing attention on management of challenging populations of children and echoes a broad range of factors related to diabetes care, including team cohesiveness, coordination of care and goal setting. Our data suggest that achievement of glycaemic consistency within a clinic could be used as a separate performance indicator in addition to average glycaemic levels.

This is the first study to quantify the impact of clinic context on glycaemic control of children with Type 1 diabetes. We used a multilevel analytical approach which provides a robust framework for analysing hierarchical data. The large number of clinics provided high power to test for random effects. Also, the use of national audit data means the results of our study have strong external validity and are directly relevant to clinical practice.

Our results should be interpreted in the context of potential limitations. First, this was a cross-sectional analysis which precludes us from making any causal inferences. Although an effort was made to adjust for important glycaemic determinants which are exogenous to the clinic environment, other unmeasured factors such as family environment, parental education, prevalence of comorbidities, and health-risk behaviours were not taken into account. Moreover, since no individual-level indicators of socio-economic status were available, we used small-area deprivation as a proxy variable which might have led to residual confounding. In this regard, attribution of residual clinic differences to differences in quality of diabetes care should be done with caution (37). Second, the use of routinely collected data meant we had no control over potential errors during data collection or data entry. Third, some children attending the same clinic might also come from the same neighbourhood in which case clinic effects might also reflect the existence of underlying small-area effects. To explore this, cross-classified models were constructed, but the proportion of variance at the level of the clinic remained unaffected. Finally, although HbA_{1c} measurements were based on standardised values, variation due to differences in laboratory methods between clinics cannot be excluded.

Conclusion

We analysed national audit data from children with Type 1 diabetes in England and Wales and found significant differences between diabetes clinics over and above individual characteristics. However, clinic differences accounted for only a small portion of the total variation in glycaemic control since most of the variation was within clinics. This implies that quality improvement might best be achieved not only by targeting poor centres but also by "shifting the curve" of overall paediatric diabetes practice towards higher quality levels.

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Conflicts of Interest

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Author contributions

All co-authors have fulfilled authorship criteria per ICMJE guidelines, have read and approved the final manuscript. DC conceptualised the analytic plan, cleaned and analysed the data, interpreted the results, drafted and revised the paper. TS conceptualised the study, helped with clinical interpretation of results and critically reviewed the paper. RV provided expertise on study methodology and clinical interpretation of findings and critically reviewed the paper. GMT provided statistical expertise and reviewed early versions of the paper. RA, JW, and VMP helped with interpretation of findings and critically reviewed the paper. TS and DC are guarantors of the study, had full access to all of the data in the study and affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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Tables

Table 1. Characteristics of children and diabetes clinics included in the study.

	No of children (%)	Median % [a] (middle 50% range) across clinics
Age (years)		
0-4	1,203 (5.5)	5.4 (4.0 to 6.8)
5-11	7,656 (35.2)	35.1 (30.2 to 40.0)
12-18	12,914 (59.3)	59.9 (54.3 to 64.5)
Gender:		
Male	11,444 (52.6)	52.2 (49.4 to 55.6)
Female	10.329 (47.4)	47.8 (44.4 to 50.6)
Diabetes duration (years)		
< 1	3,606 (16.6)	16.4 (13.8 to 19.6)
1	2,618 (12.0)	12.0 (10.3 to 14.0)
2 - 4	6,628 (30.4)	30.0 (27.5 to 33.5)
≥5	8,921 (41.0)	41.4 (37.4 to 44.9)
Index of multiple deprivation quintile [b]		
1 (least deprived)	4,359 (20.0)	16.1 (7.1 to 26.3)
2	4,354 (20.0)	19.4 (13.8 to 26.3)
3	4,354 (20.0)	19.4 (14.6 to 24.6)
4	4,352 (20.0)	20.1 (13.7 to 26.4)
5 (most deprived)	4,354 (20.0)	15.1 (8.3 to 29.6)
Ethnicity		
White	17,317 (79.5)	90.5 (68.1 to 97.8)
Asian	1,083 (5.0)	1.1 (0 to 6.0)
Mixed	575 (2.6)	1.4 (0 to 3.2)
Black	409 (1.9)	0 (0 to 1.1)
Other	305 (1.4)	0 (0 to 1.3)
Not reported	2,084 (9.6)	0 (0 to 6.5)
Insulin regimen		
≤ 3 daily injections	2,825 (13.0)	5.6 (1.2 to 17.6)
≥ 4 daily injections	12,761 (58.6)	66.8 49.6 to 79.8)
Insulin pump therapy	3,254 (15.0)	12.8 (1.3 to 24.8)
Missing	2,933 (13.5)	0 (0 to 2.5)
Overall	21,773	-

[a] Percentage of children in each group were calculated for each clinic.
[b] A UK-wide index of multiple deprivation score for both England and Wales was developed using England as a reference population and following methodology described by Payne and Abel (2012)
Note: percentages may not add up to 100 due to rounding.

Table 2. Proportion of variance in children's glycaemic control attributable to differences between clinics

	Unadjusted model [a]	**Case-mix adjusted model [b]**	**Case-mix adjusted + insulin regimen [c]**	**Case-mix adjusted + clinic volume**	**Case-mix adjusted + networks [d]**	**Case-mix adjusted + clinic HbA_{1c}-SD**
Components of variance in HbA_{1c}	Variance (SE)	Variance (SE)	Variance (SE)	Variance (SE)	Variance (SE)	Variance (SE)
Between clinics	16.4 (2.1)	12.4 (1.6)	11.8 (1.5)	11.9 (1.5)	11.0 (1.4)	6.0 (0.9)
Within clinics	287.6 (2.9)	249.5 (2.4)	246.6 (2.4)	249.5 (2.4)	249.5 (2.4)	249.5 (2.4)
% of total variance attributable to differences between clinics - ICC	5.4%	4.7%	4.6%	4.5%	4.2%	2.4%
-2Log likelihood	185,408	182,295	-	182,290	182,277	182,195

Two-level models with a random effect for clinic. SE=standard error, ICC=Intraclass Correlation Coefficient.
[a] No explanatory variables
[b] Adjusted for age, gender, diabetes duration, age-duration interaction, ethnicity, and deprivation
[c] Data for insulin regimen were missing for 2,933 children (13.5%) and were imputed using multiple imputation
[d] 11 regional diabetes networks

Table 3. Number of children (%) with different levels of glycaemic control by clinic glycaemic performance

Individual HbA_{1c}	Clinic glycaemic performance			Total
	Better than average (n=34)	Average (n=107)	Poorer than average (n=35)	
<58 mmol/mol (7.5%)	1,389 (36%)	2,022 (52%)	474 (12%)	3,885
58-80 mmol/mol (7.5%-8.5%)	3,178 (26%)	7,122 (58%)	2,055 (17%)	12,355
>80 mmol/mol (8.5%)	848 (15%)	3,139 (57%)	1,546 (28%)	5,533

Note: percentages refer to the total number of children in each glycaemic category and may not add up to 100 due to rounding. Classification of clinics into categories is based on the 95% confidence intervals of the clinic estimates obtained from the case-mix adjusted two-level model. Adjustment was made for individual gender, age, duration of diabetes, ethnicity, and deprivation.

Figures

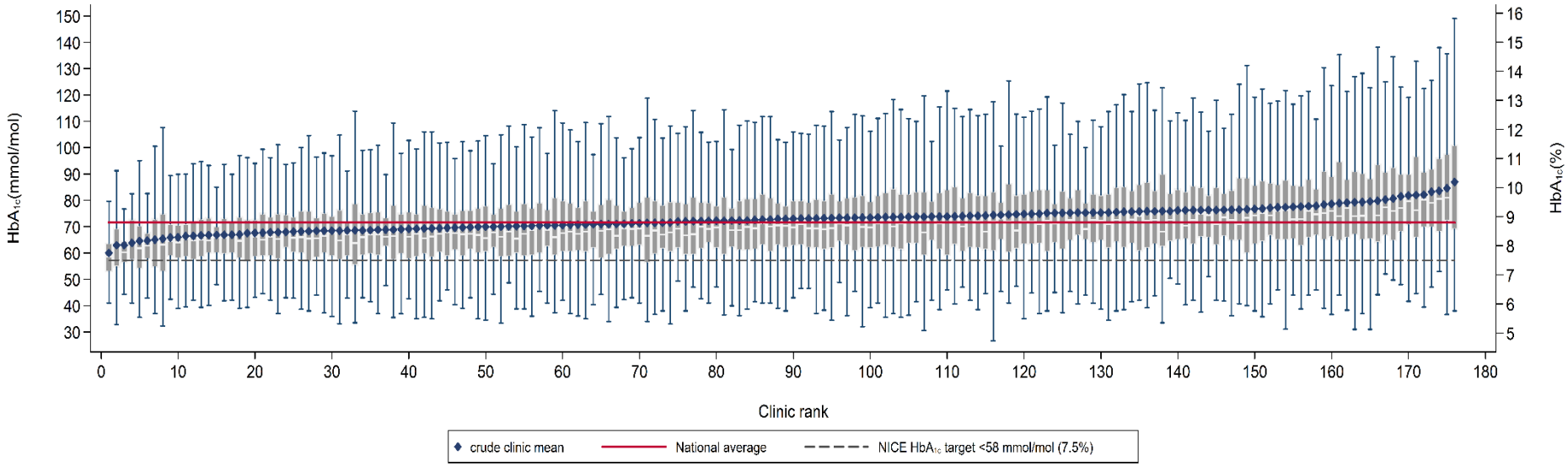

Figure 1. Box and whisker plots showing variation in HbA_{1c} within each of the 176 diabetes clinics in England and Wales. Clinics are ranked according to their crude mean HbA_{1c} (blue diamonds). Clinic means vary around the national average of 72 mmol/mol (8.8%) as represented by the red horizontal line. Dashed line represents the NICE HbA_{1c} recommended target at the time of the study. Individual outlying HbA_{1c} values are not shown.

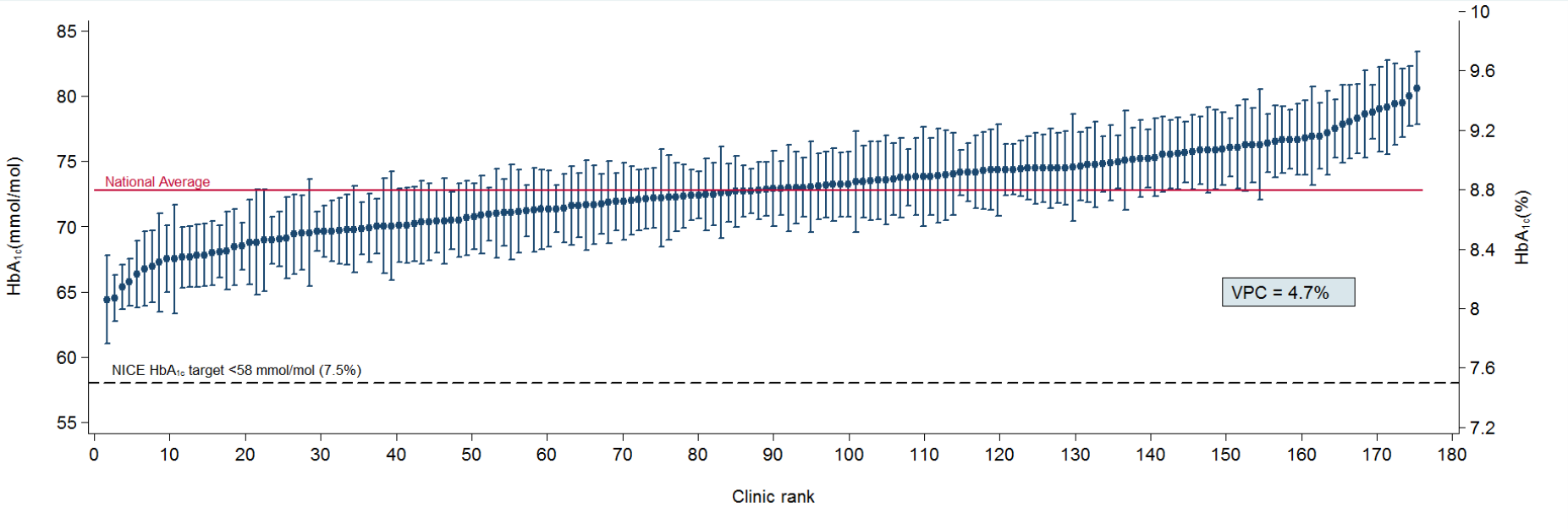

Figure 2. Estimates of clinic means with 95% confidence intervals after adjustment for differences in case-mix characteristics of children regarding age, gender, diabetes duration, ethnicity, and deprivation. Estimates derived from a two-level model with a random effect for clinic. Clinics are ranked according to their mean HbA_{1c} using the average HbA_{1c} value as a reference (red horizontal line). Dashed line represents the NICE HbA_{1c} recommended target at the time of the study.

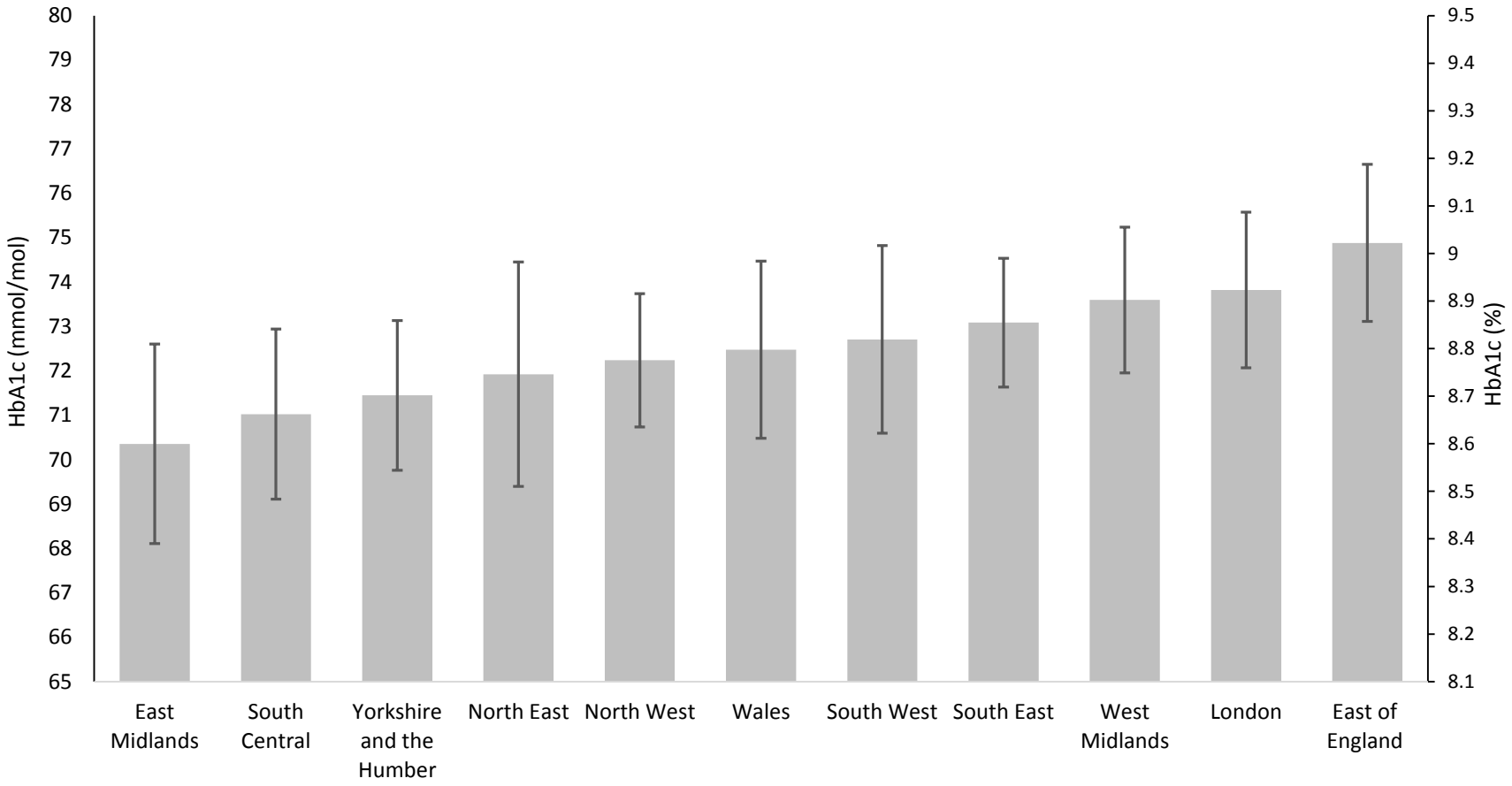

Figure 3. Predicted mean HbA_{1c} levels for the 11 Paediatric Diabetes Networks after adjusting for individual case-mix characteristics (age, gender, diabetes duration, ethnicity, and deprivation) and differences between clinics.

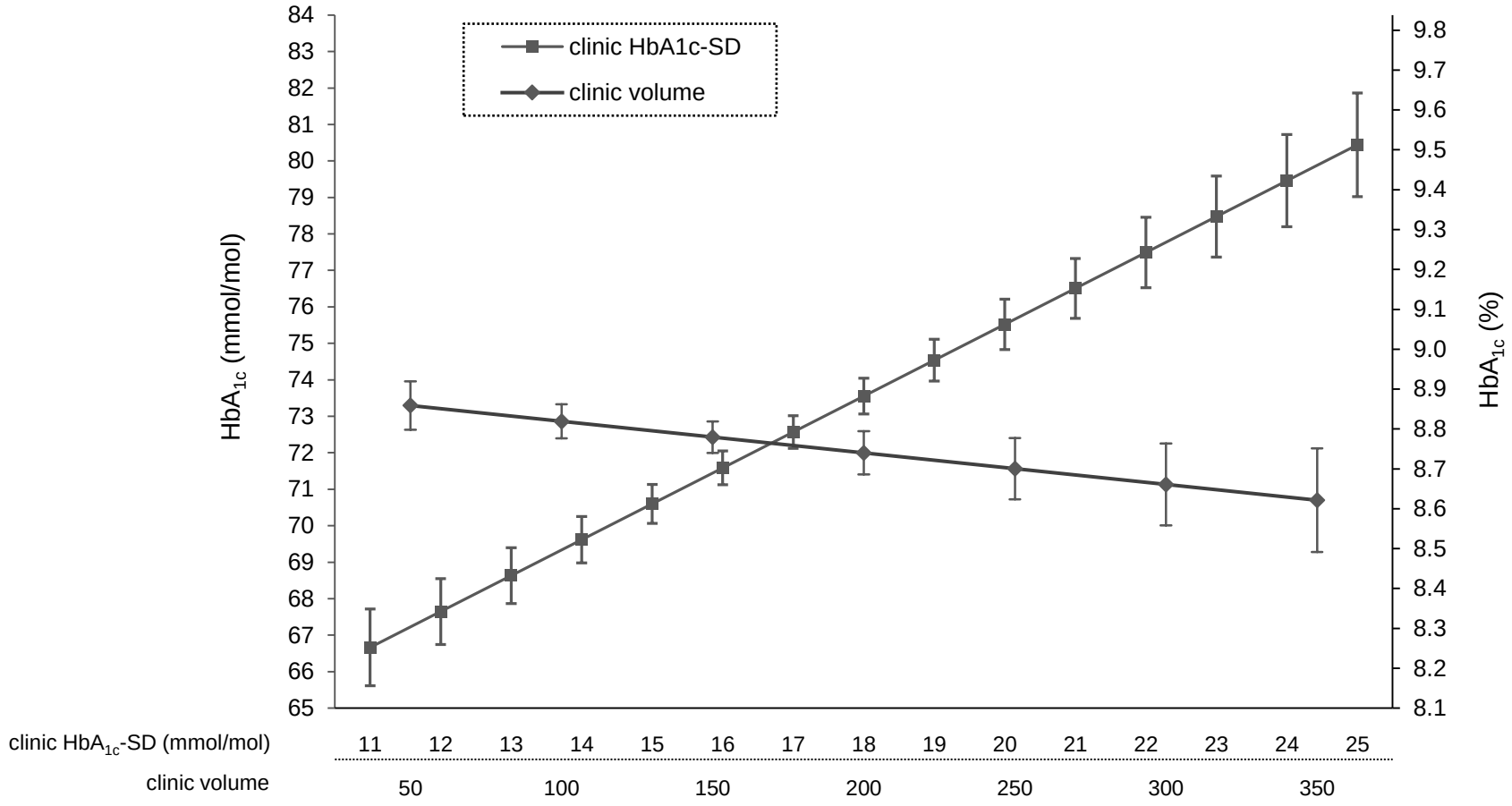

Figure 4. Association between within-clinic variability (HbA_{1c}-SD), clinic volume and predicted HbA_{1c} levels. Results from two-level model with a random effect for clinic, adjusted for case-mix characteristics (age, gender, diabetes duration, ethnicity, and deprivation). Clinic volume and clinic HbA_{1c}-SD entered simultaneously in the model.